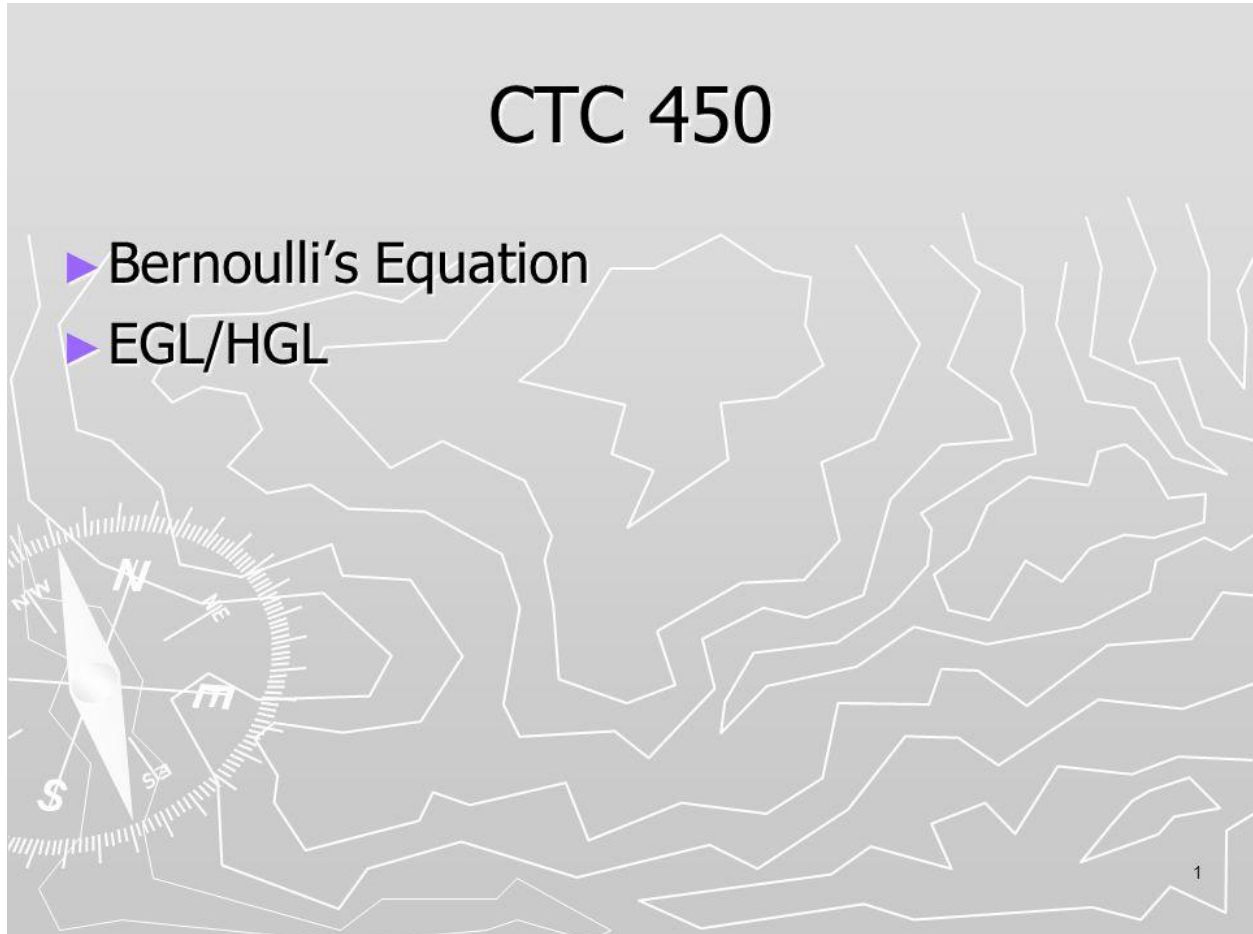


# CTC 450 Bernoulli's Equation EGL/HGL.

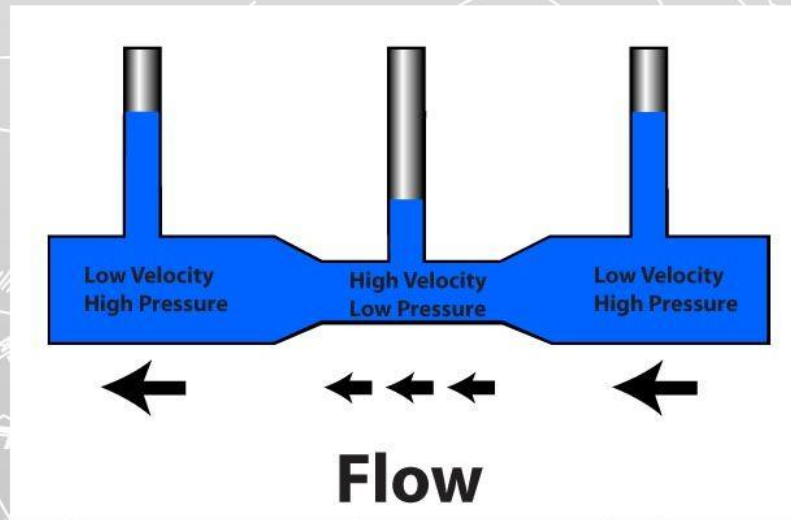
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## 1. CTC 450 Bernoulli's Equation EGL/HGL



## 2. Bernoulli's Equation

# Bernoulli's Equation



[http://www.rcuniverse.com/magazine/article\\_display.cfm?article\\_id=455](http://www.rcuniverse.com/magazine/article_display.cfm?article_id=455)

### 3. Preview Bernoulli's Equation EGL/HGL graphs

Kinetic Energy-velocity head Pressure energy-pressure head Potential Energy EGL/HGL graphs Energy grade line Hydraulic grade line

## Preview

### ► Bernoulli's Equation

- Kinetic Energy-velocity head
- Pressure energy-pressure head
- Potential Energy

### ► EGL/HGL graphs

- Energy grade line
- Hydraulic grade line

#### 4. Objectives Know how to apply the Bernoulli's equation

Know how to create EGL/HGL graphs

## Objectives

- ▶ Know how to apply the Bernoulli's equation
- ▶ Know how to create EGL/HGL graphs



## 5. Assumptions Steady flow (no change w/ respect to time)

Incompressible flow Constant density Frictionless flow Irrotational flow

# Assumptions

- ▶ Steady flow (no change w/ respect to time)
- ▶ Incompressible flow
- ▶ Constant density
- ▶ Frictionless flow
- ▶ Irrotational flow

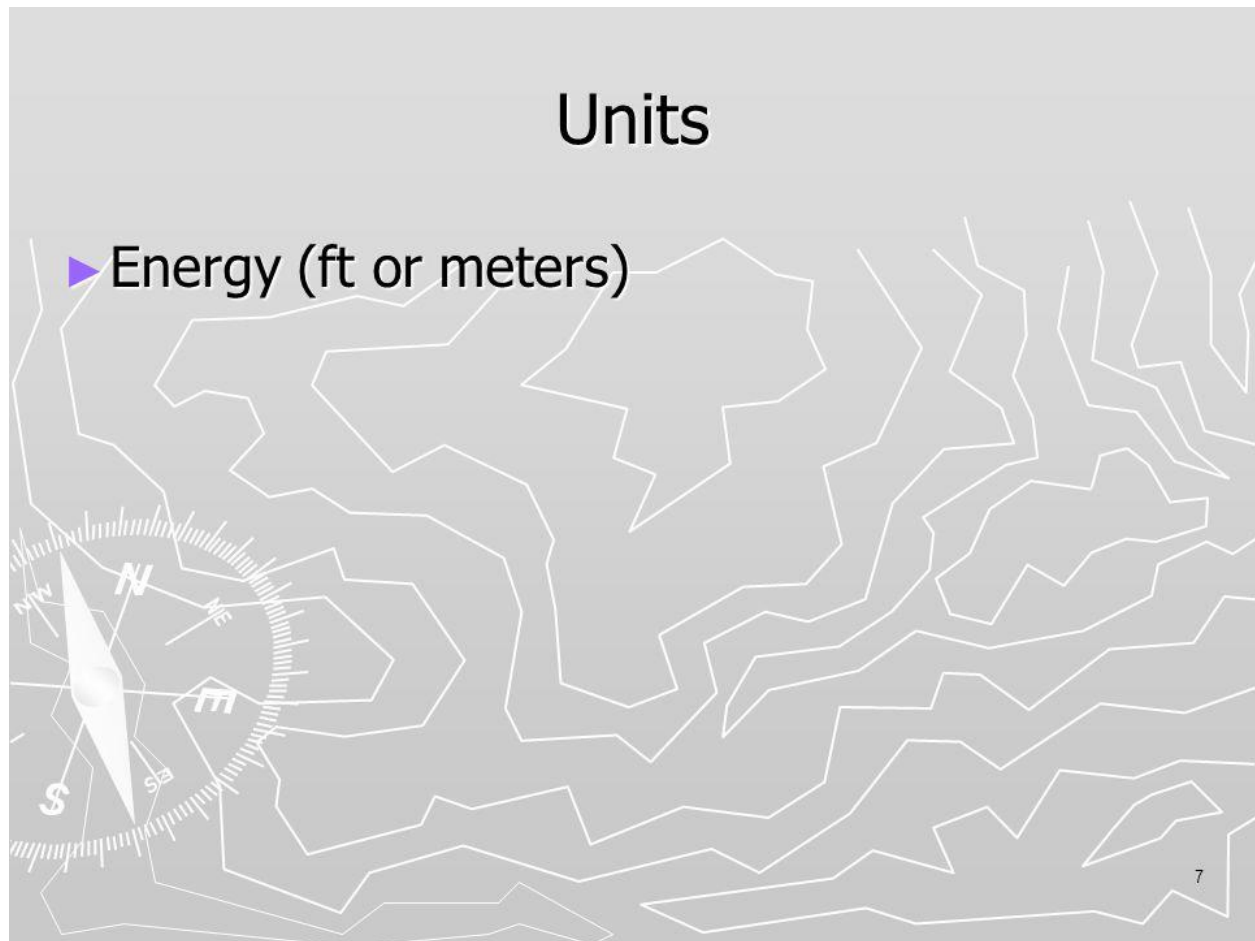
**6. Three Forms of Energy** Kinetic energy (velocity) Potential energy (gravity)  
Pressure Energy (pump/tank)

## 3 Forms of Energy

- ▶ Kinetic energy (velocity)
- ▶ Potential energy (gravity)
- ▶ Pressure Energy (pump/tank)

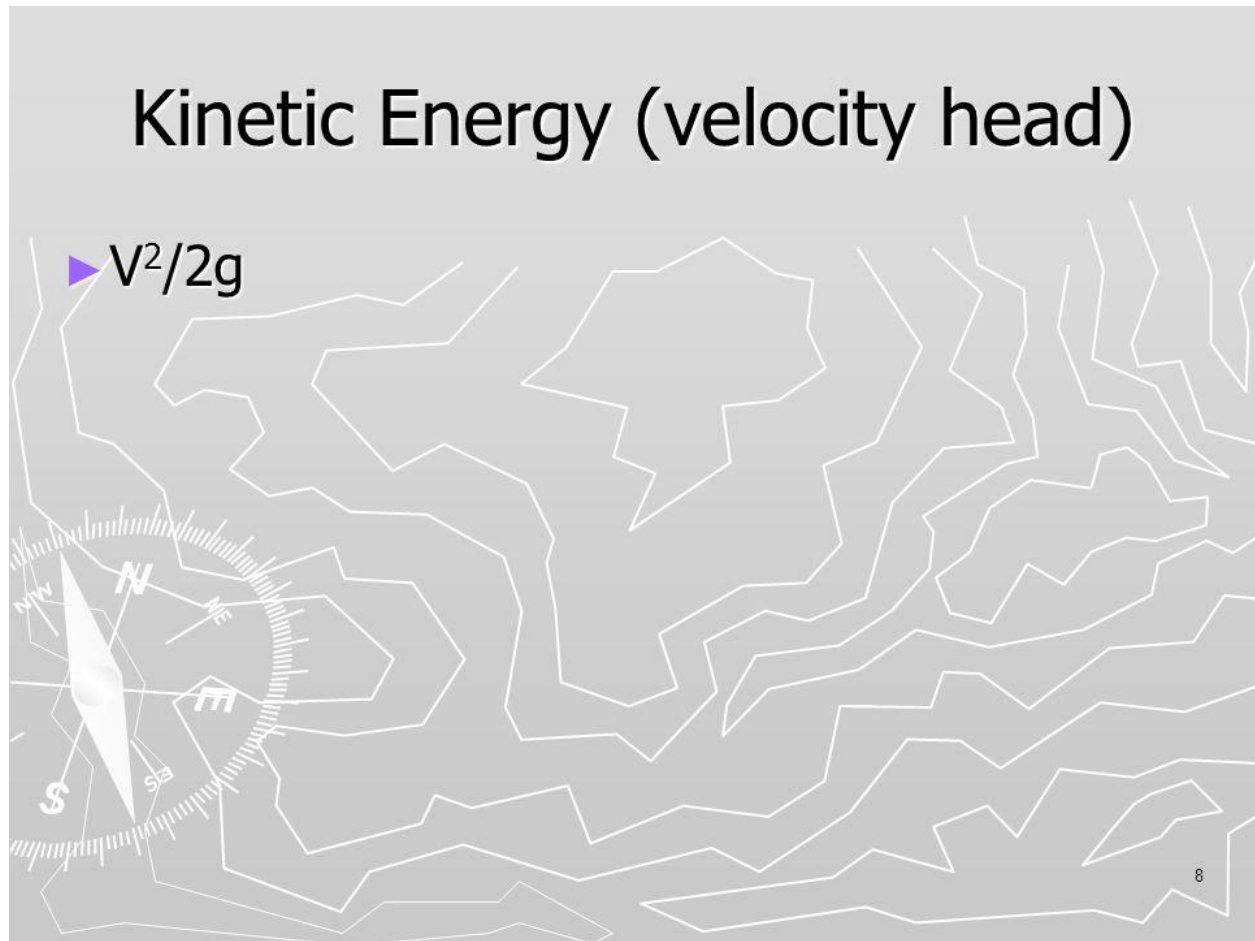


## 7. Units Energy (ft or meters)



## 8. Kinetic Energy (velocity head)

$V^2/2g$



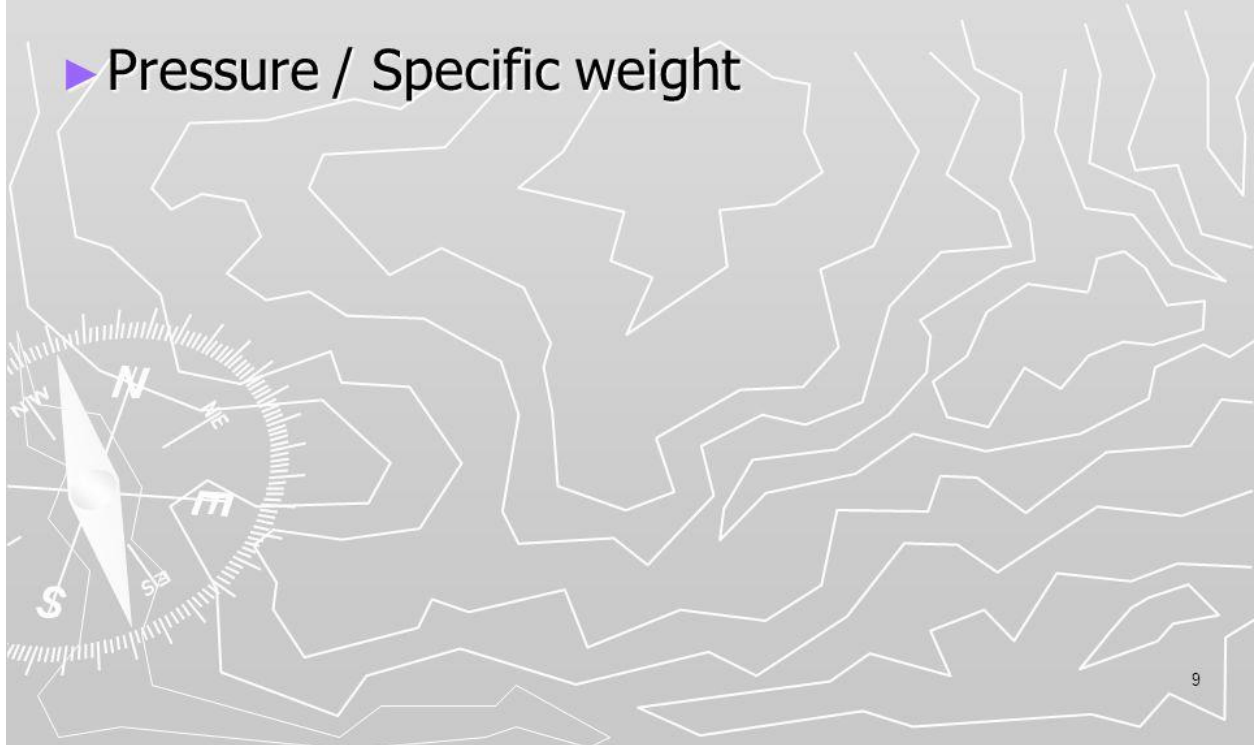


## 9. Pressure Energy (pressure head)

Pressure / Specific weight

# Pressure Energy (pressure head)

► Pressure / Specific weight

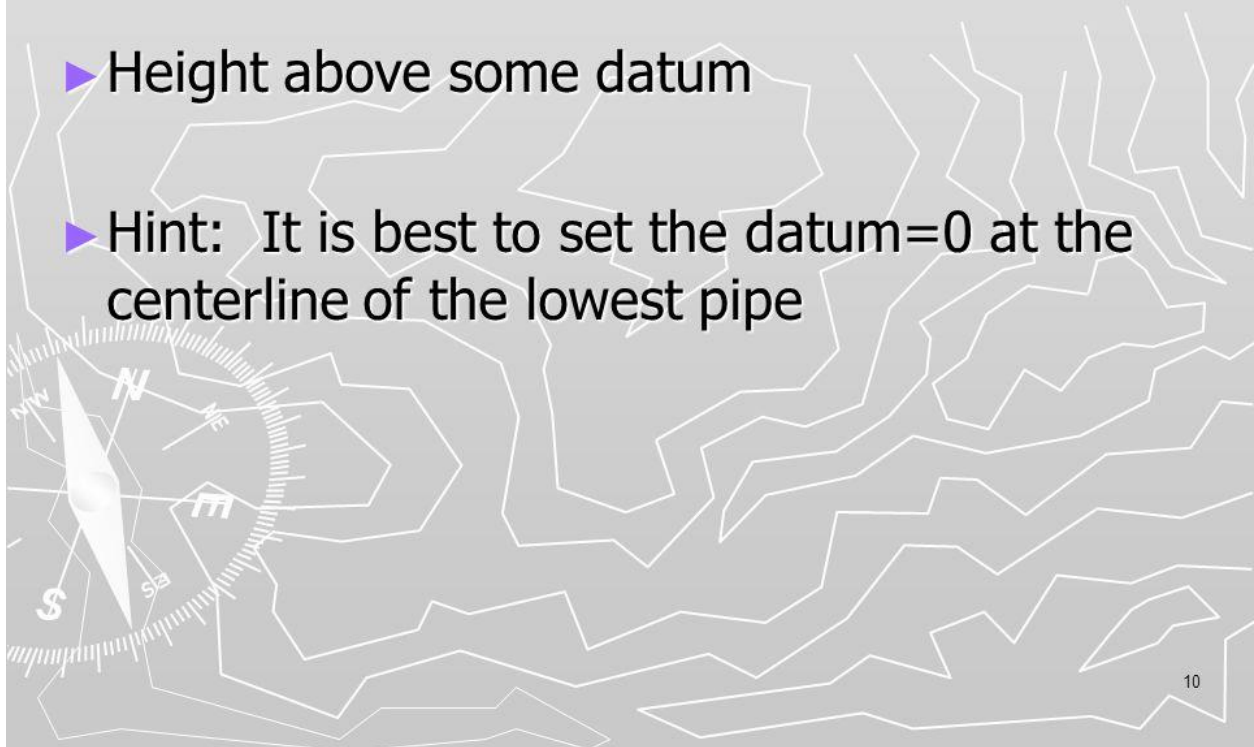


## 10. Potential Energy Height above some datum

Hint: It is best to set the datum=0 at the centerline of the lowest pipe

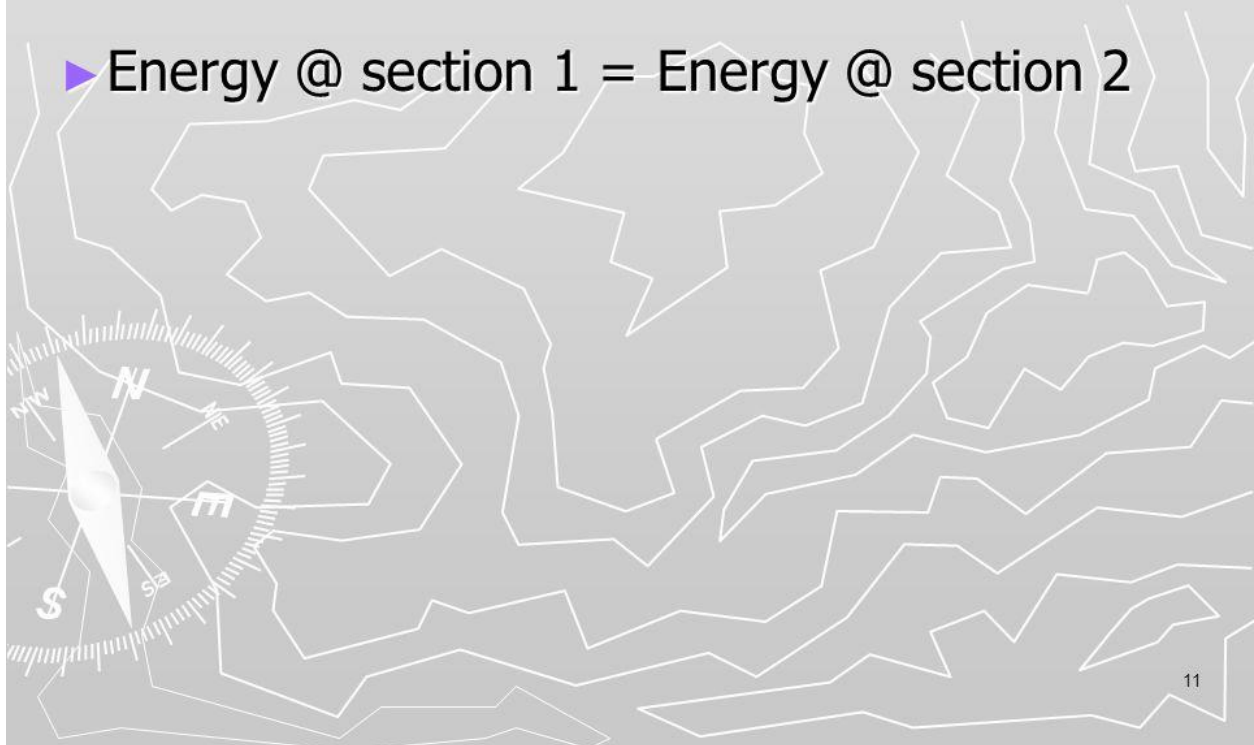
# Potential Energy

- ▶ Height above some datum
- ▶ Hint: It is best to set the datum=0 at the centerline of the lowest pipe



# Bernoulli's equation

► Energy @ section 1 = Energy @ section 2



12. **Hints:** If there is a reservoir (or large tank) pick a point at the surface of the water. The kinetic energy and pressure energy are zero, leaving only the potential energy. If water is discharging to the atmosphere pick a point just outside the pipe. The pressure energy=0.

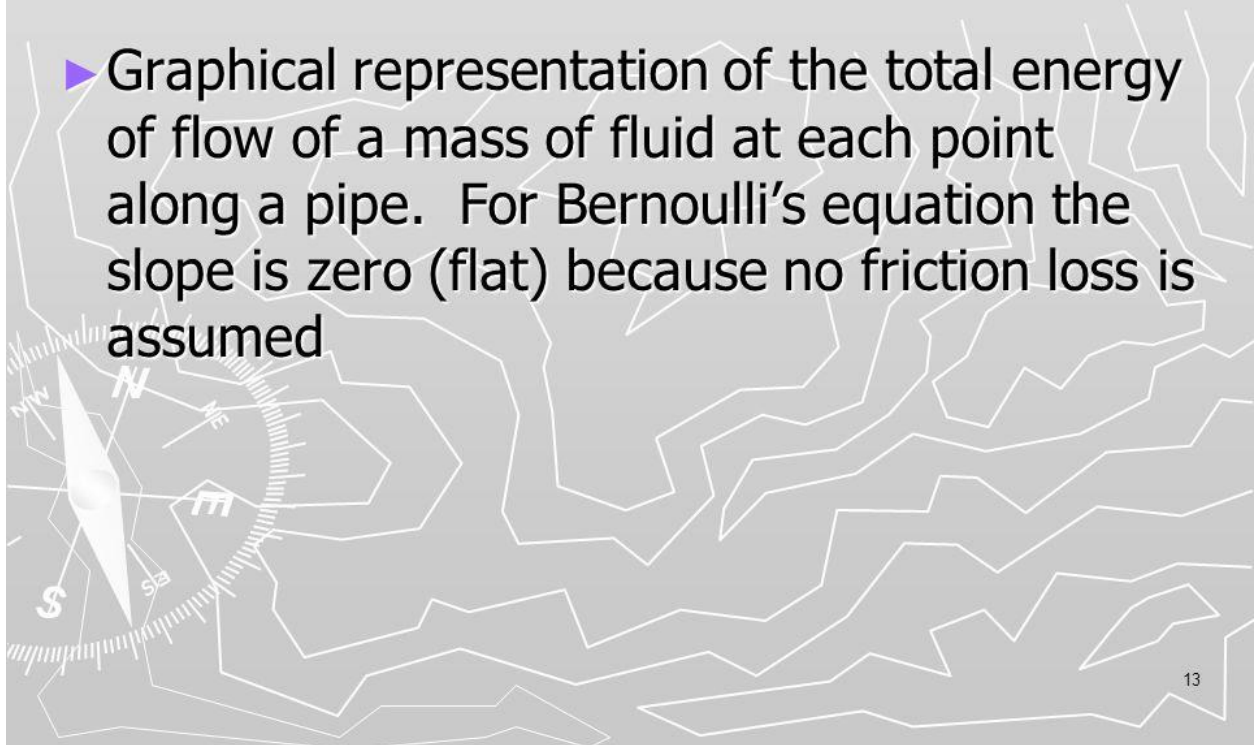
## Hints:

- ▶ If there is a reservoir (or large tank) pick a point at the surface of the water. The kinetic energy and pressure energy are zero, leaving only the potential energy.
- ▶ If water is discharging to the atmosphere pick a point just outside the pipe. The pressure energy=0.

13. Energy Grade Line Graphical representation of the total energy of flow of a mass of fluid at each point along a pipe. For Bernoulli's equation the slope is zero (flat) because no friction loss is assumed

## Energy Grade Line

- ▶ Graphical representation of the total energy of flow of a mass of fluid at each point along a pipe. For Bernoulli's equation the slope is zero (flat) because no friction loss is assumed



14. Hydraulic Grade Line Graphical representation of the elevation to which water will rise in a manometer attached to a pipe. It lies below the EGL by a distance equal to the velocity head. EGL/HGL are parallel if the pipe has a uniform cross-section (velocity stays the same if  $Q$  &  $A$  stay the same).

## Hydraulic Grade Line

- ▶ Graphical representation of the elevation to which water will rise in a manometer attached to a pipe. It lies below the EGL by a distance equal to the velocity head.
- ▶ EGL/HGL are parallel if the pipe has a uniform cross-section (velocity stays the same if  $Q$  &  $A$  stay the same).

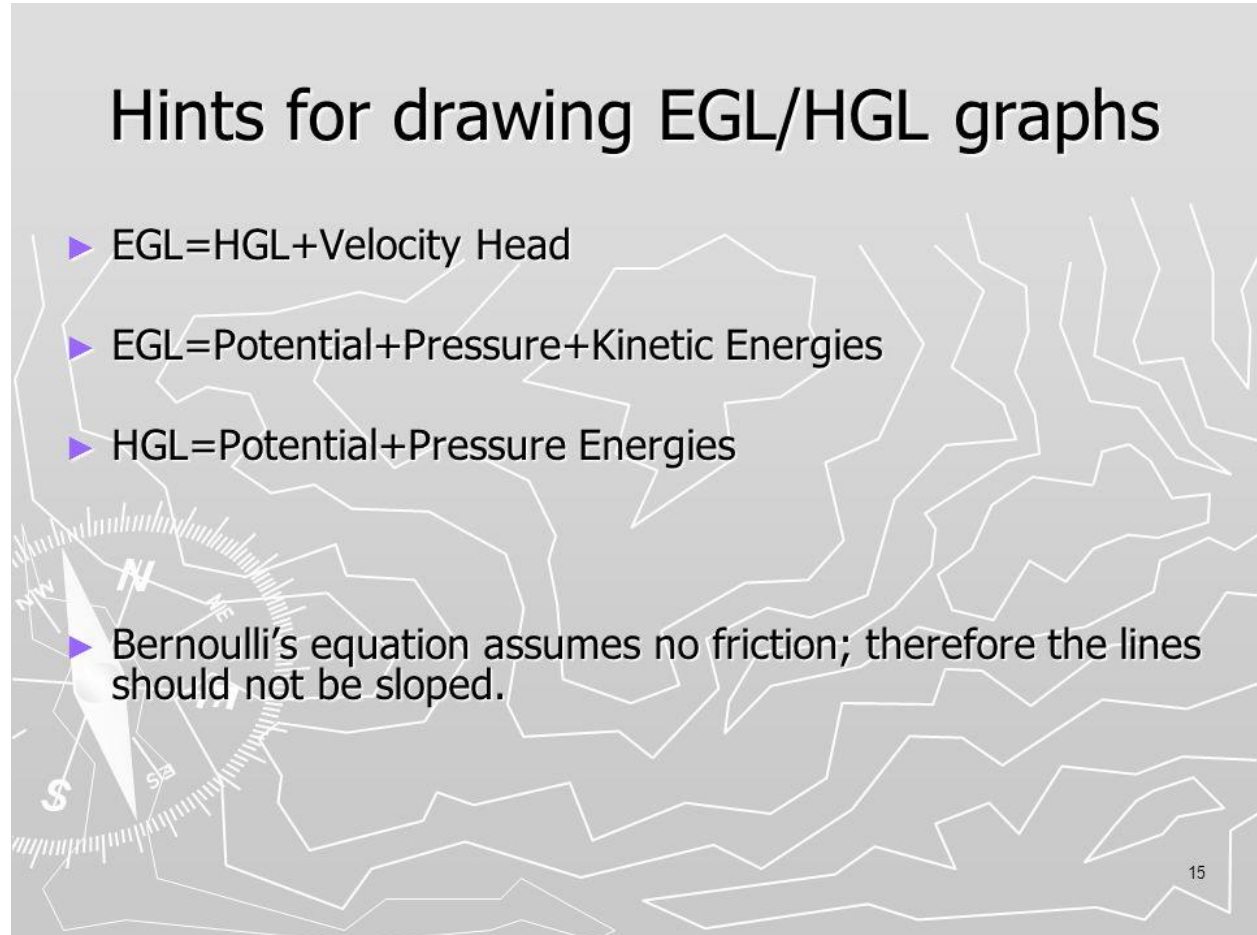


### 15. Hints for drawing EGL/HGL graphs

$EGL = HGL + \text{Velocity Head}$   
 $EGL = \text{Potential} + \text{Pressure} + \text{Kinetic Energies}$   
 $HGL = \text{Potential} + \text{Pressure Energies}$   
Bernoulli's equation assumes no friction; therefore the lines should not be sloped.

## Hints for drawing EGL/HGL graphs

- ▶  $EGL = HGL + \text{Velocity Head}$
- ▶  $EGL = \text{Potential} + \text{Pressure} + \text{Kinetic Energies}$
- ▶  $HGL = \text{Potential} + \text{Pressure Energies}$
- ▶ Bernoulli's equation assumes no friction; therefore the lines should not be sloped.

The background of the slide is a light gray topographic map with white contour lines. In the lower-left quadrant, there is a white compass rose with black markings for North (N), South (S), East (E), and West (W), and intermediate directions like NE, SE, SW, and NW. The number '15' is printed in the bottom right corner of the slide area.

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16. Reservoir Example Water exits a reservoir through a pipe. The WSE (water surface elevation) is 125' above the datum (pt A) The water exits the pipe at 25' above the datum (pt B).What is the velocity at the pipe outlet?

## Reservoir Example

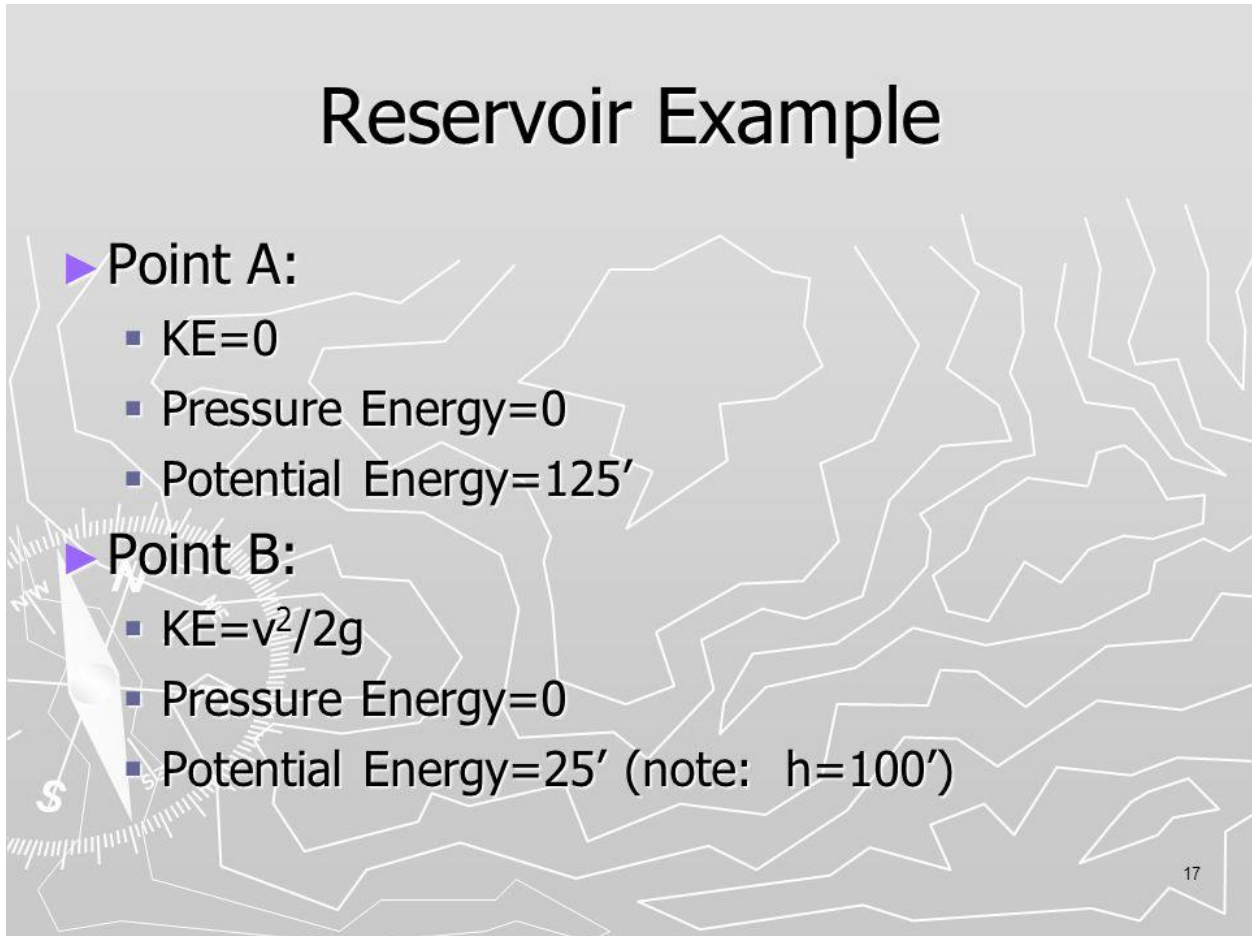
▶ Water exits a reservoir through a pipe. The WSE (water surface elevation) is 125' above the datum (pt A) The water exits the pipe at 25' above the datum (pt B).

▶ What is the velocity at the pipe outlet?



17. Reservoir Example Point A: Point B:  $KE=0$  Pressure Energy=0  
Potential Energy=125' Point B:  $KE=v^2/2g$  Potential Energy=25' (note:  $h=100'$ )

# Reservoir Example



The background of the slide is a topographic map showing a reservoir. Two points are marked on the map: Point A is at the upper left edge of the reservoir, and Point B is at the lower left edge. A dashed line connects the two points, representing a flow path. A compass rose is visible on the left side of the map, and a dollar sign (\$) is located near Point B.

- ▶ Point A:
  - $KE=0$
  - Pressure Energy=0
  - Potential Energy=125'
- ▶ Point B:
  - $KE=v^2/2g$
  - Pressure Energy=0
  - Potential Energy=25' (note:  $h=100'$ )

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18. Reservoir Example Bernoulli's: Set Pt A energy=Pt B energy  $v^2/2g=h$   
 $v=(2gh)^{.5}$  Have you seen this equation before? Velocity=80.2 ft/sec

## Reservoir Example

► Bernoulli's: Set Pt A energy=Pt B energy

- $v^2/2g=h$
- $v=(2gh)^{.5}$  Have you seen this equation before?

■ Velocity=80.2 ft/sec



### 19. Reducing Bend Example (1/5)

Water flows through a 180-degree vertical reducing bend. The diameter of the top pipe is 30-cm and reduces to 15-cm. There is 10-cm between the pipes (outside to outside). The flow is 0.25 cms. The pressure at the center of the inlet before the bend is 150 kPa. What is the pressure after the bend?

## Reducing Bend Example (1/5)

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## 20. Reducing Bend Example (2/5)

Find the velocities using the continuity equation ( $V=Q/A$ ): Velocity before bend is 3.54 m/sec Velocity after bend is m/sec

# Reducing Bend Example (2/5)

- ▶ Find the velocities using the continuity equation ( $V=Q/A$ ):
- ▶ Velocity before bend is 3.54 m/sec
- ▶ Velocity after bend is 14.15 m/sec

### 21. Reducing Bend Example (3/5)

Use Bernoulli's to solve for the pressure after the bend Kinetic + Pressure + Potential Energies before the bend = the sum of the energies after the bend Potential energy before bend =  $0.325\text{m}$  Potential energy after bend =  $0\text{m}$  (datum) The only unknown is the pressure energy after the bend.

## Reducing Bend Example (3/5)

- ▶ Use Bernoulli's to solve for the pressure after the bend
- ▶ Kinetic + Pressure + Potential Energies before the bend = the sum of the energies after the bend
- ▶ Potential energy before bend =  $0.325\text{m}$
- ▶ Potential energy after bend =  $0\text{m}$  (datum)
- ▶ The only unknown is the pressure energy after the bend.

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## 22. Reducing Bend Example (4/5)

The pressure energy after the bend=60 kPA Lastly, draw the EGL/HGL graphs depicting the reducing bend

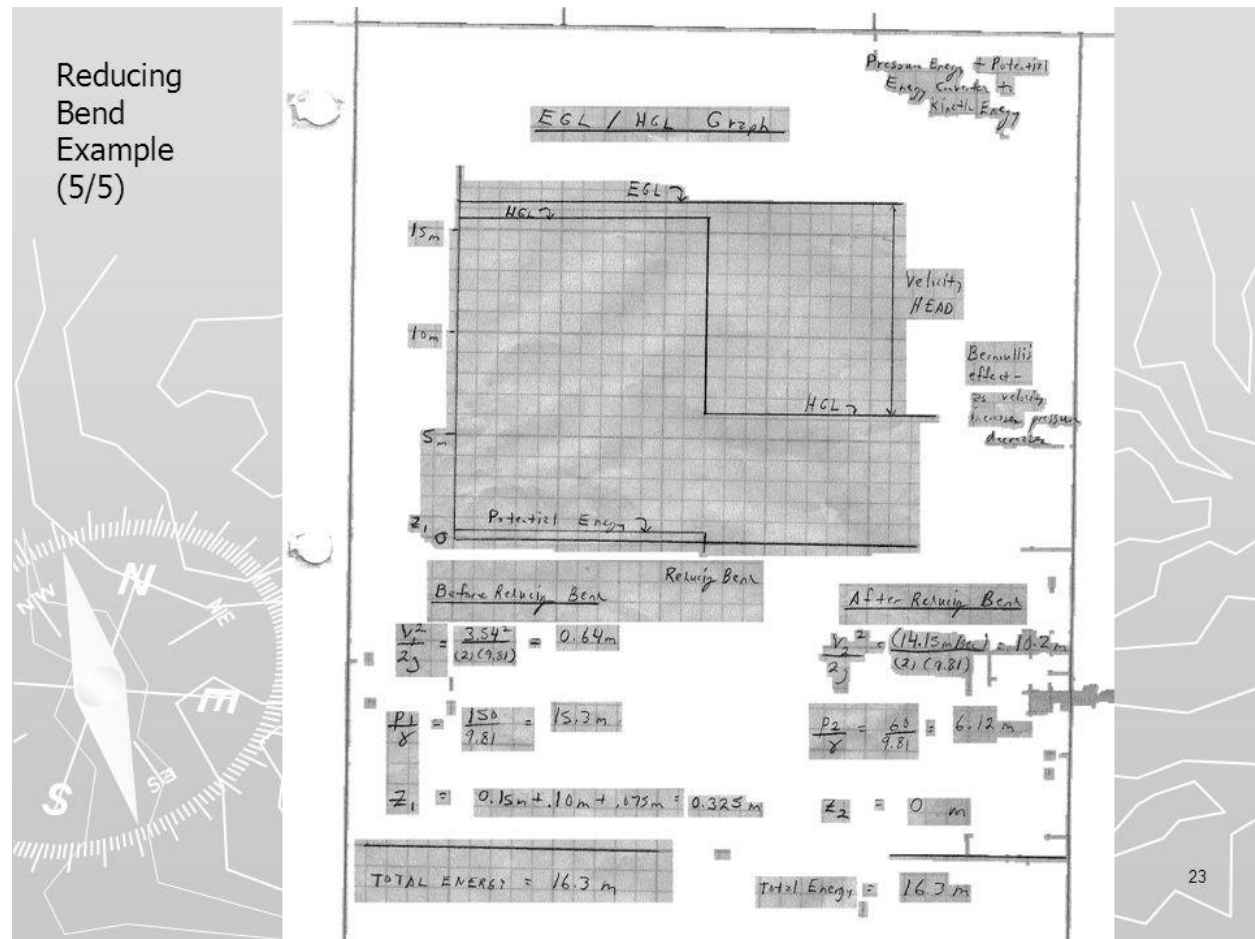
# Reducing Bend Example (4/5)

- ▶ The pressure energy after the bend=60 kPA
- ▶ Lastly, draw the EGL/HGL graphs depicting the reducing bend





### 23. Reducing Bend Example (5/5)



## 24. Next Lecture Energy equation

Accounts for friction loss, pumps and turbines

# Next Lecture

- ▶ Energy equation
- ▶ Accounts for friction loss, pumps and turbines



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